Innovations to help a key crop grow better

The International Wheat Yield Partnership (IWYP)

The Challenge

Wheat is one of the world's most important crops. Meeting future demand is a huge challenge. Annual rates of yield increase need to double by 2050, from a global average of 0.9%[1,2]. Put another way: Current increase rates would only provide 38% of the improvement required[3]. The world needs to act.

The International Wheat Yield Partnership (IWYP) was launched in 2014 to address this gap. The founders of IWYP included our Foundation. Together, they recognized that only bold approaches would deliver the necessary solutions. Their vision was to build a global network of the best minds in wheat research and plant breeding, collaborating to use the latest technologies and know-how. IWYP was also acutely aware that the yield solutions had to have positive environmental and societal results. "Doing more with less" is the continuing aim.

IWYP seeks to increase wheat's genetic yield potential by boosting the way the plant collects and uses carbon to produce grain. The partners are pursuing two main approaches. The first is to enhance wheat's photosynthetic capacity or radiation use efficiency, i.e. to convert more atmospheric carbon dioxide into plant biomass. The second approach is to maximize conversion of this biomass into more and larger grains.

At the heart of it all: The Science Program

The IWYP Science Program integrates IWYP-funded Research Projects, Aligned Projects brought in by IWYP, the expertise of its private sector partners, input from other national or international initiatives, and close partnership with CIMMYT. Today, more than 150 researchers from 60 institutions and 14 countries are working in 38 research projects to make the scientific discoveries necessary for creating higher-yielding wheat lines. These researchers are supported by a custom-made translational delivery pipeline (see below) and private partners with demonstrated expertise in delivery and Go-to-Market strategies. Major investments come from leading public funding agencies.

Partners across the world

The Syngenta Foundation is proud to have developed this public-private partnership. We are, however, just one of many organizations involved.

As of March 2020, the **funding and research organization partners** include the UK's Biotechnology and Biological Sciences Research Council (BBSRC), the Grains Research and Development Corporation of Australia (GRDC) and the Department of Biotechnology in the Ministry of Science and Technology of India (DBT). From the United States they are joined by the U.S. Agency for International Development (USAID) and the Department of Agriculture's Agriculture Research Service (USDA ARS) and National Institute of Food and Agriculture (USDA NIFA). Further funding and research organization partners are the

International Maize and Wheat Improvement Center (CIMMYT), Agriculture and Agri-Food Canada (AAFC), Institut National de la Recherche Agronomique of France (INRA) and Mexico's Ministry of Agriculture and Rural Development.

The IWYP's "**Private Member Partners**" include Syngenta, Pioneer, BASF, Limagrain, KWS, SeedCo, Mahyco, RAGT and LongReach.

IWYP Members and Contributors

Pathway to long-term impact: The IWYP Hubs

A key feature of IWYP which distinguishes it from other international programs is the IWYP Hub Network. The main Hub at CIMMYT converts elite spring wheat lines with validated outputs from the research projects into near-finished lines ('pre-products'). IWYP disseminates these to breeders globally, either for direct use as standalone varieties or as parents for varietal development.

In many parts of the world, winter wheat is more important than spring varieties. IWYP is thus establishing Winter Wheat Hubs in the US and UK. These Hubs will be public-private partnerships involving most private industry IWYP members.

Key accomplishments to date*

Scientific discoveries

IWYP and the Aligned Projects have already made many discoveries with potentially large impact on wheat yields. Significant genetic variation has been discovered in most of the target physiological processes and traits in wheat and its wild relatives. This genetic variation may be a more important source of trait-enhancement than any other variation in most breeding programs today. IWYP expects that this genetic variation will be additive and lead to major step-changes in productivity. Examples of key discoveries made by *early 2020 include wheat lines with:

- Increased final biomass, radiation use efficiency (RUE), light incidence and better chlorophyll distribution in the canopy
- Chromosome segments from wild relatives possessing larger photosynthetic efficiency than their wheat parents
- Energy use efficiency traits linked to improved yield in field trials
- Greater canopy light use efficiency, lines which have been transferred to private and public breeding programs
- High increased harvest index and lodging resistance, which can be useful as parental lines for new crosses.

Further progress includes:

- Parts of the wheat genome associated with yield and components of yield have been selected, characterized and regions refined. They are now being crossed into spring and winter wheat varieties for a comprehensive evaluation of their role in yield enhancement. This genetic variation is likely to be absent or rare in modern elite varieties.
- Germplasm and associated selectable molecular genetic markers identified for increased grain weight and spikelet number, transferred to private and public breeding programs.
- Wild wheat relatives and wheat landraces identified with greater photosynthetic efficiency than modern wheat varieties, with potential use in breeding.
- Potentially high-yielding wheat lines selected by molecular markers for yield component traits initially targeting South African environments, shared with public and private breeding programs. This illustrates the power that applying modern methods and novel genetic variation to conventional breeding programs can have in rapid and dramatic yield gains.
- Introduction of a more erect canopy phenotype into target CIMMYT wheat lines with high biomass, radiation use efficiency, harvest index and larger grains. This follows research suggesting that wheats with erect leaves generally have higher yield than those with floppy leaves.
- Genomic regions identified that enable a plant to tolerate and take up ammonium fertilizer in the presence of high carbon dioxide. (Nitrogen from the more traditional source, nitrate, becomes unavailable under these conditions). This finding suggests that it might be possible to select wheat lines able to grow and continue producing high grain and protein yields even under different climate change scenarios.
- Genes in other species shown to positively influence photosynthesis, yield and components of yield also have a positive and significant influence on these traits when transferred to wheat. These are now being combined to determine their effect on overall yield. In parallel, native genes in wheat are now being identified and tested to determine whether they have a similar effect.
- Harvest index and yield can be optimized per environment by changing certain combinations of wheat development genes, some previously known, others newly discovered by IWYP. With modeling this will be a useful decision tool for selecting combinations for different growing conditions.
- Development of new proxy high-throughput phenotyping methods to measure multiple traits in wheat plots accurately and rapidly using drones.
- Common genomic regions affecting yield, biomass and RUE identified.
- The discovery that genes related to photoprotection are prevalent in the genomic regions associated with RUE at various growth stages. This opens new avenues for marker-assisted selection of lines with higher photosynthesis and other 'source' traits, in combination with lines with a greater 'sink'.

IWYP Delivery

CIMMYT's International Wheat Information Network has disseminated germplasm under the name "Wheat Yield Consortium Yield Trial" each year on request. Yield seems to be considerably higher than with the check variety *Borlaug 100,* in lines selected from 'high biomass x high harvest index' parents. Observations that those lines with the highest biomass are enriched with exotic wheat germplasm underline the importance of 'mining' variation to achieve yield gains. Further delivery highlights include:

- In India's Punjab region, over 90,000 farmers are currently growing *Pakistan-13* (https://bit.ly/2OHnxsf). This variety was developed in part by selecting for many physiological traits that are IWYP targets.
- Wheat lines (spring and winter) with larger grains, improved quality and associated molecular genetic marker information shared with public and private wheat breeding programs.
- Early-generation pre-breeding and experimental lines, as well as information on molecular genetic markers, tools and methodologies made available to all on request via the IWYP website.
- Over 70 publications in scientific journals.
- More than 50 graduate students being trained in modern wheat genetics and breeding.

Further information

All IWYP Research and IWYP Hub outputs are made available to all. IWYP advertises widely via a variety of media and publishes outputs on its website. The “IWYP Asset Catalogue”, a research output inventory, currently features over 200 germplasm lines containing IWYP traits, 65 trait-linked molecular markers, and 16 other tools and protocols available for order and use. IWYP regularly updates the lists.

For more information on how IWYP is working hard with us and other partners to boost the genetic yield potential of wheat, please visit www.IWYP.org . (Twitter @IWYP_wheat, Facebook @IWYPnews).

Contacts

Program Director Jeff Gwyn IWYPProgdirector@IWYP.org

Program Manager Mark Sawkins IWYPProgmanager@IWYP.org

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